

EXHIBIT A

Agilent HFBR-5911L/AL LC Small Form Factor Fiber Optic Transceivers for Gigabit Ethernet Characterization Report

Application Note 1268

Summary

- The TX and RX characteristics of HFBR-5911L/AL, Agilent's new LC pin through hole gigabit ethernet transceiver, have been characterized from 0 °C to +70 °C for the HFBR-5911L and from -10 °C to +85 °C for the HFBR-5911AL. The results show that the HFBR-5911L/AL complies with or exceeds gigabit ethernet specifications.
- Typical sensitivity at room temperature is -22 dBm.

Introduction

The HFBR-5911L/AL SFF transceiver is designed to provide an IEEE 802.3 compliant link for 1.25 Gb/s applications and intended for use over the temperature range 0 °C to +70 °C for the HFBR-5911L and -10 °C to +85 °C for the HFBR-5911AL. This report details the characterization of HFBR-5911L/AL transceivers using a 50 µm fiber at -10 °C, 0 °C, +25 °C, +70 °C and +85 °C at supply voltages of 3.14 V, 3.3 V and 3.47 V. Forty transceivers were characterized at 3.3 V and +25 °C. Ten transceivers were utilized to collect data over temperature and voltage.

The modules are designed for single mode fiber and 50/62.5 µm multimode fiber and operate at a nominal wavelength of 850 nm. A PSEUDO-ECL logic interface simplifies interface to external circuitry. The transmitter section uses a Vertical Cavity Surface Emitting Laser with Class 1 eye safety. The receiver section includes a GaAs PIN photodiode mounted together with a custom silicon bipolar transimpedance preamplifier. A single 3.3 V power supply is required.

This report details the characterization work performed on the HFBR-5911L/AL Transceiver. The report evaluates the HFBR-5911L/AL performance under all conditions against target parameters in the product specification. The following parameters were evaluated over the supply voltage range at -10 °C, 0 °C, +25 °C, +70 °C and +85 °C:

Transmitter: Supply Current, Power Dissipation, Optical Power, Extinction Ratio, Optical Rise Time, Optical Fall Time and Contributed Total Jitter.

Receiver: Supply Current, Power Dissipation, Output Differential Voltage, Sensitivity, Stressed Sensitivity, SD Deassert, SD Hysteresis, SD_High V, SD_Low V, Output Rise Time, Output Fall Time.



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Exhibit A

Definition of terms

The following terms are used in this document and are explained and defined below:

Transmitter Parameters**Output Power (dBm)**

The optical output power is an averaged measurement using a 1 m LC patchcord terminated with an SC connector into a large area detector. This measurement allows for the loss of the LC Connector. The module was modulated at 1.25 Gb/s using a 2^{7-1} pseudo random bit sequence (PRBS).

Extinction Ratio (dB)

This is the ratio of optical power in a "1" or "on" logic state to the optical power in a "0" or "off" logic state. The Extinction Ratio is measured using a 2^{7-1} PRBS pattern at 1.25 Gbits/sec.

Transmitter Supply Current (mA)

This is the current supplied to the transmitter at the relevant supply voltage including that drawn by the test fixture but excluding that drawn by the termination resistance network.

Optical Rise Time (ps)

This is a measure of the Data Output transition time using a 1010 pattern from a logic low of 20% to a logic high of 80% of signal amplitude.

Optical Fall Time (ps)

This is a measure of the Data Output transition time using a 1010 pattern from a logic high of 80% to a logic low of 20% of signal amplitude.

Receiver Parameters**Sensitivity (dBm)**

This measures the receiver sensitivity with a 2^{7-1} PRBS input signal compliant to Gigabit Ethernet recommendations. The sensitivity is the minimum optical input power that the receiver can recover a signal with an error rate of $1E-12$.

Receiver Supply Current (mA)

This is the receiver supply current at the stated supply voltage, including that drawn by the termination resistance network of the evaluation board.

Signal Detect Level High (V)

The measured voltage referenced to ground at the signal detect output during an 'on' state. Referred to as SD High V in document.

Signal Detect Level Low (V)

The measured voltage referenced to ground at the signal detect output during an 'off' state. Referred to as SD Low V in document.

Signal Detect Deassert (dBm)

This is the point at which the signal detect flags low to indicate a loss of signal due to low optical power.

Output Rise Time (ps)

This is a measure of the Data Output transition time using a 1010 pattern from a logic low of 10% to a logic high of 90% of signal amplitude.

Output Fall Time (ps)

This is a measure of the Data Output transition time using a 1010 pattern from a logic high of 90% to a logic low of 10% of signal amplitude.

Characterization Results

The devices were characterized under the following conditions:

1. $V_{CC} = 3.3 \text{ V}$, 0°C to $+70^\circ\text{C}$
2. $V_{CC} = 3.47 \text{ V}$, 0°C to $+70^\circ\text{C}$
3. $V_{CC} = 3.13 \text{ V}$, 0°C to $+70^\circ\text{C}$
4. $+25^\circ\text{C}$, $V_{CC} = 3.3 \text{ V}$
5. $+70^\circ\text{C}$, $V_{CC} = 3.3 \text{ V}$
6. 0°C , $V_{CC} = 3.3 \text{ V}$
7. $+85^\circ\text{C}$, $V_{CC} = 3.13$ to 3.47 V
8. -10°C , $V_{CC} = 3.13$ to 3.47 V

Over Temperature Summary
 $(0^\circ\text{C} - +70^\circ\text{C})$ at $V_{CC} = 3.3 \text{ V}$, 3.47 V ,
 and 3.13 V .

Tables 1-3 show that HFBR-5911L sees negligible voltage dependence for major parameters over its operating temperature range of $(0^\circ\text{C} - +70^\circ\text{C})$.

Table 1 - HFBR-5911L Minimum, Mean and Maximum measured parameters over operating temperature $(0^\circ\text{C} - +70^\circ\text{C})$ at 3.3 V

+70°C) at 3.3 V						
Test Parameters	Units	Minimum	Mean	Maximum	Data Sheet Limits	
					Minimum	Maximum
Transmitter						
Supply Current	mA	43	45	53		75
Power Dissipation	mW	140	149	176		280
Optical Power	dBm	-8.6	-7.2	-6.6	-9.5	-1.5
Extinction Ratio	dB	10.4	13.0	14.4	9	
Optical Rise Time	pS	60	75	99		260
Optical Fall Time	pS	166	175	192		260
Contributed Total Jitter	pS	103	126	168		227
Receiver						
Supply Current	mA	97	103	110		135
Power Dissipation	mW	321	339	363		470
Output Differential Voltage	V	0.65	0.73	0.81	0.4	1.2
Output Rise Time	pS	173	180	197		400
Output Fall Time	pS	169	176	196		400
Sensitivity	dBm	-22.8	-22.6	-22.2		-17
Stressed Sensitivity	dBm	-20.7	-20.5	-19.2		-12.5
SD High V	V	3.2	3.3	3.3	2.2	
SD Low V	V	0.11	0.12	0.13		0.6
SD Assert	dBm	-23.7	-23.1	-22.7		-17
SD Deassert	dBm	-26.2	-25.6	-25.1	-30	
SD Hysteresis	dB	2.2	2.5	2.7	1.5	
Contributed Total Jitter	pS	131	137	146		266

Table 2 - HFBR-5911L Minimum, Mean and Maximum measured parameters over operating temperature (0°C - +70°C) at 3.47 V

+70°C) at 3.47 V						
Test Parameters	Units	Minimum	Mean	Maximum	Data Sheet Limits	
					Minimum	Maximum
<i>Transmitter</i>						
Supply Current	mA	43	46	54		75
Power Dissipation	mW	148	158	187		260
Optical Power	dBm	-8.6	-7.2	-6.6	-9.5	-1.5
Extinction Ratio	dB	10.3	13.2	14.4	9	
Optical Rise Time	pS	57	74	100		260
Optical Fall Time	pS	164	175	194		260
Contributed Total Jitter	pS	104	127	176		227
<i>Receiver</i>						
Supply Current	mA	103	108	116		135
Power Dissipation	mW	356	373	401		470
Output Differential Voltage	V	0.66	0.74	0.82	0.4	1.2
Output Rise Time	pS	171	182	191		400
Output Fall Time	pS	162	179	197		400
Sensitivity	dBm	-22.8	-22.5	-22.0		-17
Stressed Sensitivity	dBm	-20.8	-20.5	-19.2		-12.5
SD High V	V	3.4	3.4	3.4	2.2	
SD Low V	V	0.11	0.12	0.14		0.6
SD Assert	dBm	-23.7	-23.2	-22.7		-17
SD Deassert	dBm	-26.3	-26.7	-25.1	-30	
SD Hysteresis	dB	2.2	2.5	2.7	1.5	
Contributed Total Jitter	pS	129	139	154		266

Table 3 - HFBR-5911L Minimum, Mean and Maximum measured parameters over operating temperature (0°C - +70°C) at 3.13 V

Table 3 - Transmitter
+70°C) at 3.13 V

Test Parameters	Units	Minimum	Mean	Maximum	Data Sheet Limits	
					Minimum	Maximum
<i>Transmitter</i>						
Supply Current	mA	42	45	53		75
Power Dissipation	mW	131	141	167		260
Optical Power	dBm	-8.8	-7.2	-6.6	-9.5	-1.5
Extinction Ratio	dB	10.1	12.9	14.2	9	
Optical Rise Time	pS	57	75	103		260
Optical Fall Time	pS	167	175	193		260
Contributed Total Jitter	pS	99	124	170		227
<i>Receiver</i>						
Supply Current	mA	92	98	105		135
Power Dissipation	mW	289	306	330		470
Output Differential Voltage	V	0.64	0.71	0.79	0.4	1.2
Output Rise Time	pS	172	181	195		400
Output Fall Time	pS	166	174	203		400
Sensitivity	dBm	-22.9	-22.6	-22.2		-17
Stressed Sensitivity	dBm	-20.8	-20.5	-19.2		-12.5
SD High V	V	3.1	3.1	3.1	2.2	
SD Low V	V	0.10	0.11	0.13		0.8
SD Assert	dBm	-23.5	-23.0	-22.6		-17
SD Deassert	dBm	-26.0	-25.5	-25.0	-30	
SD Hysteresis	dB	2.2	2.5	2.7	1.5	
Contributed Total Jitter	pS	123	140	153		286

Tables 4-6 show a summary of parametric performance at nominal 3.3 V supply at +25°C, +70°C, and 0°C. The results show that all parameters are within data sheet limits.

Table 4 - HFBR-5911L Minimum, Mean and Maximum measured parameters at +25°C and 3.3 V

Table 4 - HFBR-5911L Minimum, Mean and Maximum measured parameters at 25°C						
Test Parameters	Units	Minimum	Mean	Maximum	Data Sheet Limits	
					Minimum	Maximum
<i>Transmitter</i>						
Supply Current	mA	43	45	52		75
Power Dissipation	mW	140	149	172		260
Optical Power	dBm	-7.9	-7.2	-6.8	-9.5	-1.5
Extinction Ratio	dB	11.6	13.0	14.1	9	
Optical Rise Time	pS	60	75	92		260
Optical Fall Time	pS	170	175	181		260
Contributed Total Jitter	pS	180	126	146		227
<i>Receiver</i>						
Supply Current	mA	100	103	105		135
Power Dissipation	mW	331	339	347		470
Output Differential Voltage	V	0.70	0.73	0.75	0.4	1.2
Output Rise Time	pS	173	180	186		400
Output Fall Time	pS	170	176	181		400
Sensitivity	dBm	-22.8	-22.6	-22.4		-17
Stressed Sensitivity	dBm	-20.7	-20.5	-20.2		-12.5
SD High V	V	3.3	3.3	3.3	2.2	
SD Low V	V	0.11	0.12	0.12		0.6
SD Assert	dBm	-23.6	-23.1	-22.9		-17
SD Deassert	dBm	-26.0	-25.6	-25.5	-30	
SD Hysteresis	dB	2.3	2.5	2.6	1.5	
Contributed Total Jitter	pS	132	137	144		266

Table 5 - HFBR-5911L Minimum, Mean and Maximum measured parameters at +70°C and 3.3 V

Table 5 - HFBR-5911L Minimum, Mean and Maximum measured parameters at +70 °C and 0.5 V						
Test Parameters	Units	Minimum	Mean	Maximum	Data Sheet Limits	
					Minimum	Maximum
<i>Transmitter</i>						
Supply Current	mA	43	48	53		75
Power Dissipation	mW	140	152	176		260
Optical Power	dBm	-8.6	-7.7	-6.7	-9.5	-1.5
Extinction Ratio	dB	12.4	13.8	14.4	9	
Optical Rise Time	pS	65	77	88		260
Optical Fall Time	pS	176	183	192		260
Contributed Total Jitter	pS	103	111	128		227
<i>Receiver</i>						
Supply Current	mA	106	108	110		135
Power Dissipation	mW	349	356	363		470
Output Differential Voltage	V	0.77	0.79	0.81	0.4	1.2
Output Rise Time	pS	181	187	197		400
Output Fall Time	pS	185	190	196		400
Sensitivity	dBm	-22.6	-22.4	-22.2		-17
Stressed Sensitivity	dBm	-20.7	-20.2	-19.2		-12.5
SD High V	V	3.2	3.2	3.2	2.2	
SD Low V	V	0.13	0.13	0.13		0.6
SD Assert	dBm	-23.3	-22.9	-22.7		-17
SD Deassert	dBm	-25.5	-25.2	-25.1	-30	
SD Hysteresis	dB	2.2	2.4	2.5	1.5	
Contributed Total Jitter	pS	131	139	146		266

Table 6 - HFBR-5911L Minimum, Mean and Maximum measured parameters at 0°C and 3.3 V

Table 6 - HFBR-5911L Minimum, Mean and Maximum measured parameters at 0 °C and 25 °C						
Test Parameters	Units	Minimum	Mean	Maximum	Data Sheet Limits	
					Minimum	Maximum
<i>Transmitter</i>						
Supply Current	mA	43	46	53		75
Power Dissipation	mW	142	153	176		260
Optical Power	dBm	-7.7	-7.2	-6.6	-9.5	-1.5
Extinction Ratio	dB	10.4	11.8	12.9	9	
Optical Rise Time	pS	64	77	99		260
Optical Fall Time	pS	166	173	184		260
Contributed Total Jitter	pS	119	144	168		227
<i>Receiver</i>						
Supply Current	mA	97	100	103		135
Power Dissipation	mW	321	329	339		470
Output Differential Voltage	V	0.65	0.67	0.70	0.4	1.2
Output Rise Time	pS	173	180	191		400
Output Fall Time	pS	169	176	184		400
Sensitivity	dBm	-22.7	-22.4	-22.2		-17
Stressed Sensitivity	dBm	-20.6	-20.4	-20.2		-12.5
SD High V	V	3.3	3.3	3.3	2.2	
SD Low V	V	0.11	0.11	0.11		0.6
SD Assert	dBm	-23.7	-23.2	-22.9		-17
SD Deassert	dBm	-26.2	-25.8	-25.6	-30	
SD Hysteresis	dB	2.5	2.6	2.7	1.5	
Contributed Total Jitter	pS	132	140	146		266

Tables 7 - 8 show a summary of parametric performance at nominal 3.13 V to 3.47 V supply at +85 °C and -10 °C. The results show that all parameters are within data sheet limits.

Table 7 - HFBR-5911AL Minimum, Mean and Maximum measured parameters at +85 °C and 3.13 V to 3.47 V

Table 7 - HFBR-5911AL Minimum, Mean and Maximum Values						
Test Parameters	Units	Minimum	Mean	Maximum	Data Sheet Limits	
					Minimum	Maximum
<i>Transmitter</i>						
Supply Current	mA	42	47	54	-	75
Power Dissipation	mW	139	155	180	-	260
Optical Power	dBm	-9	-7.9	-6.7	-9.5	-1.5
Extinction Ratio	dB	11.7	13.4	14.9	9	-
Optical Rise Time	pS	65	80	100	-	260
Optical Fall Time	pS	177	188	200	-	260
Contributed Total Jitter	pS	93	110	128	-	227
<i>Receiver</i>						
Supply Current	mA	103	109	117	-	135
Power Dissipation	mW	340	360	386	-	470
Output Differential Voltage	V	0.77	0.80	0.83	0.4	1.2
Output Rise Time	pS	182	192	201	-	400
Output Fall Time	pS	190	199	214	-	400
Sensitivity	dBm	-22.7	-22.3	-21.9	-	-17
SD High V	V	3.1	3.2	3.4	2.2	-
SD Low V	V	0.13	0.13	0.14	-	0.6
SD Assert	dBm	-23.0	-22.8	-22.4	-	-17
SD Deassert	dBm	-25.4	-25.1	-24.9	-30	-
SD Hysteresis	dB	2.2	2.4	2.5	1.5	-
Contributed Total Jitter	pS	103	119	141	-	268

Table 8 - HFBR-5911AL Minimum, Mean and Maximum measured parameters at -10 °C and 3.13 V to 3.47 V

Table 5

Test Parameters	Units	Minimum	Mean	Maximum	Data Sheet Limits	
					Minimum	Maximum
<i>Transmitter</i>						
Supply Current	mA	44	48	58	-	75
Power Dissipation	mW	144	159	192	-	260
Optical Power	dBm	-8.0	-7.3	-6.6	-9.5	-1.5
Extinction Ratio	dB	9.8	11.4	13.1	9	-
Optical Rise Time	pS	64	78	103	-	260
Optical Fall Time	pS	165	173	181	-	260
Contributed Total Jitter	pS	124	156	210	-	227
<i>Receiver</i>						
Supply Current	mA	91	98	106	-	135
Power Dissipation	mW	301	324	351	-	470
Output Differential Voltage	V	0.62	0.65	0.69	0.4	1.2
Output Rise Time	pS	165	176	188	-	400
Output Fall Time	pS	157	171	179	-	400
Sensitivity	dBm	-22.8	-22.3	-21.8	-	-17
SD High V	V	3.1	3.3	3.4	2.2	-
SD Low V	V	0.1	0.1	0.1	-	0.6
SD Assert	dBm	-23.7	-23.1	-22.7	-	-17
SD Deassert	dBm	-26.3	-25.8	-25.3	-30	-
SD Hysteresis	dB	2.5	2.7	2.8	1.5	-
Contributed Total Jitter	pS	106	116	128	-	266

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Exhibit A
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